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(54) Title: FLEXIBLE SPLICE PROTECTOR ASSEMBLY AND METHOD FOR PREPARING SAME

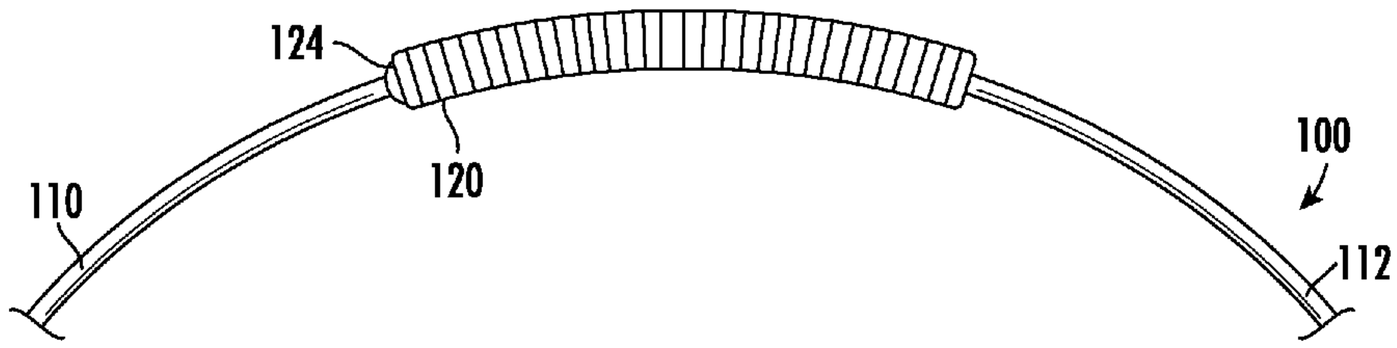


FIG. 1

(57) Abstract: An assembly includes: first and second fiber optic cables, each of the first and second fiber optic cables including an exposed portion of an optical fiber and an overlying jacket, wherein the optical fiber of the first fiber optic cable is fusion spliced to the optical fiber of the second fiber optic cable to form a splice area; a splice protector that surrounds the splice area of the first and second fiber optic cables; a flexible tube that encircles the splice protector, the exposed portions of the first and second fiber optic cables, and end portions of the jackets of the first and second fiber optic cables, wherein the splice protector, the exposed portions of optical fibers of the first and second fiber optic cables reside in a lumen of the flexible tube; first and second adhesive barriers positioned between an inner surface of the flexible tube and the end portions of the first and second fiber optic cables, respectively; and an outer sleeve that circumferentially overlies the flexible tube and portions of the jackets of the first and second fiber optic cables.

[Continued on next page]

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FLEXIBLE SPLICE PROTECTOR ASSEMBLY AND METHOD FOR PREPARING SAME

Related Application

[0001] The present application claims priority from and the benefit of U.S. Provisional Patent Application No. 62/944,125, filed December 5, 2019, the disclosure of which is hereby incorporated herein by reference in full.

Field of the Invention

[0002] The present invention relates generally to spliced cable and/or spliced optical fiber protectors.

Background

[0003] Optical fibers of fiber optic cables (either individual fibers or groups of fibers, such as ribbon fibers) are often spliced together to enable the transmission of signals between two cables. Fusion splicing is the process of fusing or welding two fibers together, usually by an electric arc. Fusion splicing is the most widely used method of splicing of optical fibers and fiber optic cables, as it typically provides for the lowest loss and least reflectance, as well as providing the strongest and most reliable joint between two fibers.

[0004] It may be desirable to provide techniques for enhancing fusion splicing operations, particularly in the field or in a warehouse.

Summary

[0005] As a first aspect, embodiments of the invention are directed to an assembly comprising: first and second fiber optic cables, each of the first and second fiber optic cables including an exposed portion of an optical fiber and an overlying jacket, wherein the optical fiber of the first fiber optic cable is fusion spliced to the optical fiber of the second fiber optic cable to form a splice area; a splice protector that surrounds the splice area of the first and second fiber optic cables; a flexible tube that encircles the splice protector, the exposed portions of the first and second fiber optic cables, and end portions of the jackets of the first and second fiber optic cables, wherein the splice protector, the exposed portions of optical fibers of the first and second fiber optic cables reside in a lumen of the flexible tube; first and second adhesive barriers positioned between an inner surface of the flexible tube and the end portions of the first and second fiber optic cables, respectively; and an outer sleeve that circumferentially overlies the flexible tube and portions of the jackets of the first and second fiber optic cables.

[0006] As a second aspect, embodiments of the invention are directed to an assembly comprising: first and second fiber optic cables, each of the first and second fiber optic cables including an exposed portion of an optical fiber and an overlying jacket, wherein the optical fiber of the first fiber optic cable is fusion spliced to the optical fiber of the second fiber optic cable to form a splice area; a splice protector that surrounds the splice area of the first and second fiber optic cables; a flexible corrugated tube that encircles the splice protector, the exposed portions of the first and second fiber optic cables, and end portions of the jackets of the first and second fiber optic cables, wherein the splice protector, the exposed portions of optical fibers of the first and second fiber optic cables reside in a lumen of the flexible tube; first and second adhesive barriers positioned between an inner surface of the flexible tube and the end portions of the first and second fiber optic cables, respectively; and an outer sleeve formed of a heat-shrinkable material that circumferentially overlies the flexible tube and portions of the jackets of the first and second fiber optic cables.

[0007] As a third aspect, embodiments of the invention are directed to an assembly comprising: first and second fiber optic cables, each of the first and second fiber optic cables including an exposed portion of an optical fiber and an overlying jacket, wherein the optical fiber of the first fiber optic cable is fusion spliced to the optical fiber of the second fiber optic cable to form a splice area; a splice protector that surrounds the splice area of the first and second fiber optic cables; a flexible tube that encircles the splice protector, the exposed portions of the first and second fiber optic cables, and end portions of the jackets of the first and second fiber optic cables, wherein the splice protector, the exposed portions of optical fibers of the first and second fiber optic cables reside in a lumen of the flexible tube; first and second adhesive barriers positioned between an inner surface of the flexible tube and the end portions of the first and second fiber optic cables, respectively; first and second dams attached to, respectively, the end portions of the jackets of the first and second fiber optic cables; and an outer sleeve formed of a heat-shrinkable material that circumferentially overlies the flexible tube and portions of the jackets of the first and second fiber optic cables.

Brief Description of the Figures

[0008] **FIG. 1** is a top perspective view of a spliced fiber optic assembly according to embodiments of the invention, wherein the outer sleeve is omitted.

[0009] **FIG. 2** is a top perspective view of the assembly of **FIG. 1**, wherein a portion of the tube has been cut away to illustrate the splice protector and the exposed fiber portions of the cables.

[0010] **FIG. 3** is a top perspective view of the assembly of **FIG. 1**.

[0011] **FIG. 4** is a partial top section view of an assembly according to alternative embodiments of the invention.

Detailed Description

[0012] The present invention now is described more fully hereinafter with reference to the accompanying drawings, in which embodiments of the invention are shown. This invention may, however, be embodied in many different forms and should not be construed as limited to the embodiments set forth herein; rather, these embodiments are provided so that this disclosure will

be thorough and complete, and will fully convey the scope of the invention to those skilled in the art.

[0013] In the figures, certain layers, components or features may be exaggerated for clarity, and broken lines illustrate optional features or operations unless specified otherwise. This invention may, however, be embodied in many different forms and should not be construed as limited to the embodiments set forth herein; rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey the scope of the invention to those skilled in the art.

[0014] It will be understood that, although the terms first, second, etc. may be used herein to describe various elements, components, regions, layers and/or sections, these elements, components, regions, layers and/or sections should not be limited by these terms. These terms are only used to distinguish one element, component, region, layer or section from another region, layer or section. Thus, a first element, component, region, layer or section discussed below could be termed a second element, component, region, layer or section without departing from the teachings of the present invention. The sequence of operations (or steps) is not limited to the order presented in the claims or figures unless specifically indicated otherwise.

[0015] Unless otherwise defined, all terms (including technical and scientific terms) used herein have the same meaning as commonly understood by one of ordinary skill in the art to which this invention belongs. It will be further understood that terms, such as those defined in commonly used dictionaries, should be interpreted as having a meaning that is consistent with their meaning in the context of the specification and relevant art and should not be interpreted in an idealized or overly formal sense unless expressly so defined herein. Well-known functions or constructions may not be described in detail for brevity and/or clarity.

[0016] The terminology used herein is for the purpose of describing particular embodiments only and is not intended to be limiting of the invention. As used herein, the singular forms "a", "an" and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will be further understood that the terms "comprises" and/or "comprising", when used in this specification, specify the presence of stated features, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components, and/or groups thereof. As

used herein, the term "and/or" includes any and all combinations of one or more of the associated listed items.

[0017] As used herein, phrases such as "between X and Y" and "between about X and Y" should be interpreted to include X and Y. As used herein, phrases such as "between about X and Y" mean "between about X and about Y." As used herein, phrases such as "from about X to Y" mean "from about X to about Y."

[0018] Referring now to the figures, an assembly, designated broadly at **100**, is illustrated in **FIGS. 1-3**. The assembly **100** comprises two fiber optic cables **110, 112** that are fusion spliced, as evidenced by a splice protector **114** (see **FIG. 2** - although in some embodiments multiple splice protectors may be present). Exposed (and in some cases buffered) portions **116** of the fibers are present on either side of the splice protector **114**. Each of the cables **110, 112** also includes a jacket **118**.

[0019] As shown in **FIG. 1** (and partially shown in **FIG. 2**), the assembly **100** includes a hollow, flexible tube **120**. The flexible tube **120**, which is typically formed of a flexible polymeric material such as nylon or PTFE, circumferentially surrounds the splice protector **114**, the exposed portions **116**, and the end portions of the jackets **118** of the fiber optics cables **110, 112**. In the illustrated embodiment, the tube **120** includes corrugations **122**, which can contribute to the flexibility (in both the axial and transverse directions) of the assembly **100**. In some embodiments the tube **120** may be smooth, or may include a textured surface (e.g., an abraded surface).

[0020] The positioning of the exposed portions **116** of the fiber optic cables **110, 112** and the splice protector **114** within the lumen of the tube **120** can allow the exposed portions **116** and the splice protector **114** to "float" within the tube **120,** and further allows for some bending of the fibers to occur in routing. The permitted float and bending can be beneficial due to the potential length and narrowness of the assembly **100**. A flexible tube may be advantageous compared to a solid tube in that breakage is less of a concern (due to narrowness and length) and a flexible tube is easier to route inside enclosures. By permitting float of the splice protector **114** and the exposed portions **116**, slight bends are of less concern because there is room for the fibers to adjust.

[0021] The assembly **100** also includes adhesive barriers **124** that underlie the ends of the tube **120**. The adhesive barriers **124** (which are typically formed of a "non-sag" adhesive, i.e., one that tends to remain in place, rather than flowing, prior to curing) attach the tube **120** to the jacket **118**, and also to any strength members (such as aramid yarns) that are present in the cables **110, 112**. The adhesive barriers **124** lock the cables **110, 112** in place to prevent any fiber movement on either side of the assembly **110**. The bond to the cable jacket **118** can prevent cable-to-tube rotation. The bonding onto the strength member(s) can provide the assembly **100** with pull strength. Moreover, if a corrugated tube **120** is employed, the corrugations **122** can enhance the pull strength compared to a smooth wall tube, as the adhesive of the adhesive barrier **124** fills the interior ridges between corrugations **122**. In some instances the adhesive barriers **124** do not extend to the exposed portions **116** of the fibers, in which case the fibers are able to "float" relative to the jacket **118**.

[0022] The adhesive may be dispensed via one or more fill holes in the tube **120**; in a typical embodiment, the fill holes are typically positioned near the ends of the tube **120** (e.g., within 0.5 to 1 inch of the ends of the tube **120**). Adhesive is injected through the fill holes such that the adhesive is forced to fill the space between the inner surface of the tube **120** and portions of the jacket **118** of the cables **110, 112**. The adhesive is then permitted to cure in these locations to form the adhesive barriers **124**. In some embodiments, any strength member that is present is exposed so that the adhesive can be directed into contact with it, thereby marrying the adhesive barrier **124** with the strength member.

[0023] In other instances, the adhesive may be injected directly into the lumen of the tube **120** through the open ends of the tube **120**.

[0024] Referring now to **FIG. 3**, the assembly **100** further comprises an outer sleeve **130** that circumferentially overlies the tube **120** and portions of the cables **110, 112** adjacent the ends of the tube **120.** The outer sleeve **130** may be formed of a heat-shrinkable material, a cold-shrinkable material, or some other suitable material. The sleeve **130** can provide pull strength, and can limit the bending of the assembly **100** (as it may provide greater rigidity than the tube **120**). The outer sleeve **130** can act as a limiter to prevent highly flexible tubes **120** from bending too much and causing fiber kinks, particularly at the interface of the splice protector **114**. The combination of tube **120** and outer sleeve **130** can provide a desirable balance of

flexibility/rigidity for routing and protection, depending on the size and proposed location and use of the assembly **100**.

[0025] In some embodiments, the outer sleeve **130** may be adhesive-backed (i.e., it may have adhesive on its inner surface. Many flexible tubes, such as the tube **120**, can stretch considerably under load, particularly when corrugated. An adhesive-backed outer sleeve **130** can limit the allowable movement and elongation. (Although in some embodiments in which the tube **120** has corrugations, shrinking of the outer sleeve tube **130** into the corrugations may preclude the need for an adhesive-backed outer sleeve **130**).

[0026] As is also shown in **FIG. 3**, the outer sleeve **130** may further be circumferentially surrounded by a second outer sleeve **135**. The combination of two outer sleeves **130, 135** may provide a different balance of flexibility/rigidity, and may also provide additional strain relief. In some embodiments, both outer sleeves **130, 135** are heat-shrink sleeves.

[0027] Referring now to **FIG. 4**, a portion of an alternative assembly **100'** is shown therein. The assembly **100'** is similar to the assembly **100**, but includes dams **140** that encircle the jackets **118** of the cables **110, 112** at their ends (one dam **140** is shown in **FIG. 4**). In some embodiments, the dam **140** may comprise an O-ring attached to the end of the jacket **118**. The dam **140** can block adhesive flow with no concern about overflow onto the fiber, as the dam **140** can block the flow and cause the adhesive instead to flow back out of the initial opening. In such instances, the fibers may be free to "float" relative to the jacket **118.** In addition, the dam **140** can separate and isolate any strength member so it can be consistently bonded with the jacket **118** (normally the strength member resides with the fibers). The assembly **100'** includes the tube **120** (shown in **FIG. 4** as being smooth rather than corrugated), the outer sleeve **130,** and the second outer sleeve **135** discussed above.

[0028] In some embodiments, the fusion-spliced assemblies **100, 100'** can be relatively compact (compared, for example, with typical splice trays), such that much shorter lengths of fibers (e.g., a total spliced length between the two fibers of 3 to 6 inches) may be spliced.

[0029] Also, in some embodiments the adhesive barriers may be omitted, such that the outer sleeves(s) **130, 135** are sufficient to fix the assembly relative to the splice area.

[0030] The foregoing is illustrative of the present invention and is not to be construed as limiting thereof. Although a few exemplary embodiments of this invention have been described,

those skilled in the art will readily appreciate that many modifications are possible in the exemplary embodiments without materially departing from the novel teachings and advantages of this invention. Accordingly, all such modifications are intended to be included within the scope of this invention as defined in the claims. The invention is defined by the following claims, with equivalents of the claims to be included therein.

That Which is Claimed is:

1. An assembly, comprising:

first and second fiber optic cables, each of the first and second fiber optic cables including an exposed portion of an optical fiber and an overlying jacket, wherein the optical fiber of the first fiber optic cable is fusion spliced to the optical fiber of the second fiber optic cable to form a splice area;

a splice protector that surrounds the splice area of the first and second fiber optic cables;

a flexible tube that encircles the splice protector, the exposed portions of the first and second fiber optic cables, and end portions of the jackets of the first and second fiber optic cables;

wherein the splice protector, the exposed portions of optical fibers of the first and second fiber optic cables reside in a lumen of the flexible tube;

first and second adhesive barriers positioned between an inner surface of the flexible tube and the end portions of the first and second fiber optic cables, respectively; and

an outer sleeve that circumferentially overlies the flexible tube and portions of the jackets of the first and second fiber optic cables.

2. The assembly defined in Claim 1, wherein the flexible tube includes a plurality of corrugations.

3. The assembly defined in Claim 1 or Claim 2, wherein the outer sleeve comprises a heat-shrinkable material.

4. The assembly defined in Claim 3, wherein the outer sleeve is adhesive-backed on an inner surface thereof.

5. The assembly defined in any of Claims 1-4, wherein the outer sleeve is a first outer sleeve, and wherein a second outer sleeve circumferentially surrounds the first outer sleeve.

6. The assembly defined in Claim 5, wherein both the first outer sleeve and the second outer sleeve comprise a heat-shrinkable material.

7. The assembly defined in any of Claims 1-6, wherein the flexible tube comprises first and second fill holes in fluid communication with the first and second adhesive barriers.

8. The assembly defined in any of Claims 1-7, wherein the adhesive barriers comprise a non-sag adhesive.

9. The assembly defined in any of Claims 1-8, further comprising first and second dams attached to, respectively, the end portions of the jackets of the first and second fiber optic cables.

10. The assembly defined in Claim 9, wherein the first and second dams comprise first and second O-rings.

11. An assembly, comprising:

first and second fiber optic cables, each of the first and second fiber optic cables including an exposed portion of an optical fiber and an overlying jacket, wherein the optical fiber of the first fiber optic cable is fusion spliced to the optical fiber of the second fiber optic cable to form a splice area;

a splice protector that surrounds the splice area of the first and second fiber optic cables;

a flexible corrugated tube that encircles the splice protector, the exposed portions of the first and second fiber optic cables, and end portions of the jackets of the first and second fiber optic cables;

wherein the splice protector, the exposed portions of optical fibers of the first and second fiber optic cables reside in a lumen of the flexible tube;

first and second adhesive barriers positioned between an inner surface of the flexible tube and the end portions of the first and second fiber optic cables, respectively; and

an outer sleeve formed of a heat-shrinkable material that circumferentially overlies the flexible tube and portions of the jackets of the first and second fiber optic cables.

12. The assembly defined in Claim 11, wherein the flexible tube comprises first and second fill holes in fluid communication with the first and second adhesive barriers.

13. The assembly defined in Claim 11 or Claim 12, wherein the adhesive barriers comprise a non-sag adhesive.

14. The assembly defined in any of Claims 11-13, wherein the outer sleeve is a first outer sleeve, and wherein a second outer sleeve circumferentially surrounds the first outer sleeve.

15. The assembly defined in Claim 14, wherein both the first outer sleeve and the second outer sleeve comprise a heat-shrinkable material.

16. The assembly defined in any of Claims 11-15, further comprising first and second dams attached to, respectively, the end portions of the jackets of the first and second fiber optic cables.

17. The assembly defined in Claim 16, wherein the first and second dams comprise first and second O-rings.

18. An assembly, comprising:

first and second fiber optic cables, each of the first and second fiber optic cables including an exposed portion of an optical fiber and an overlying jacket, wherein the optical fiber

of the first fiber optic cable is fusion spliced to the optical fiber of the second fiber optic cable to form a splice area;

a splice protector that surrounds the splice area of the first and second fiber optic cables;

a flexible tube that encircles the splice protector, the exposed portions of the first and second fiber optic cables, and end portions of the jackets of the first and second fiber optic cables;

wherein the splice protector, the exposed portions of optical fibers of the first and second fiber optic cables reside in a lumen of the flexible tube;

first and second adhesive barriers positioned between an inner surface of the flexible tube and the end portions of the first and second fiber optic cables, respectively;

first and second dams attached to, respectively, the end portions of the jackets of the first and second fiber optic cables; and

an outer sleeve formed of a heat-shrinkable material that circumferentially overlies the flexible tube and portions of the jackets of the first and second fiber optic cables.

19. The assembly defined in Claim 18, wherein the first and second dams comprise first and second O-rings.

20. The assembly defined in Claim 18 or Claim 19, wherein the outer sleeve is adhesive-backed on an inner surface thereof.

21. The assembly defined in any of Claims 18-20, wherein the outer sleeve is a first outer sleeve, and wherein a second outer sleeve circumferentially surrounds the first outer sleeve, and wherein the second outer sleeve comprise a heat-shrinkable material.

22. The assembly defined in any of Claims 18-21, wherein the flexible tube comprises first and second fill holes in fluid communication with the first and second adhesive barriers.

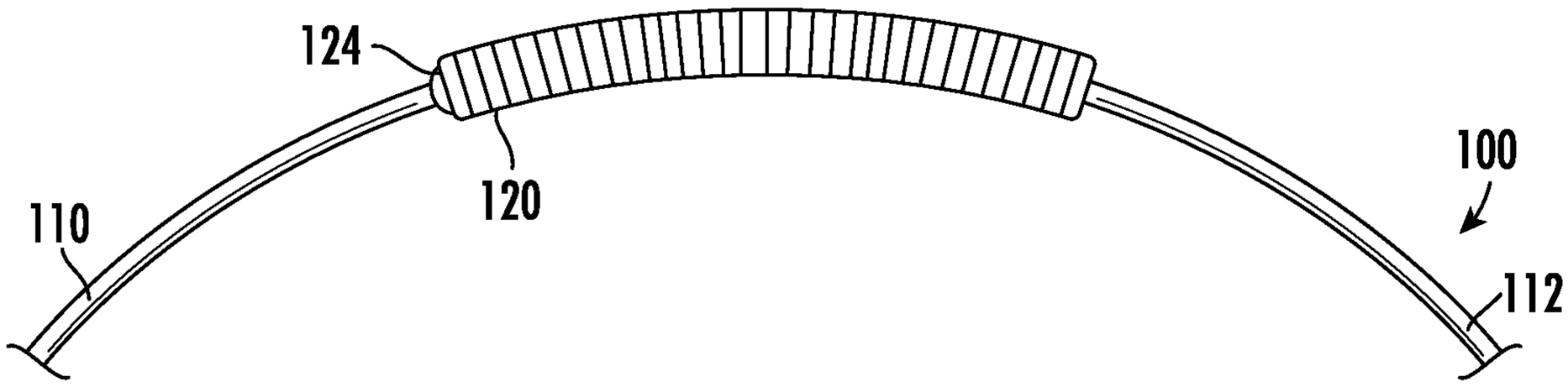

124
120
100
110
112

FIG. 1

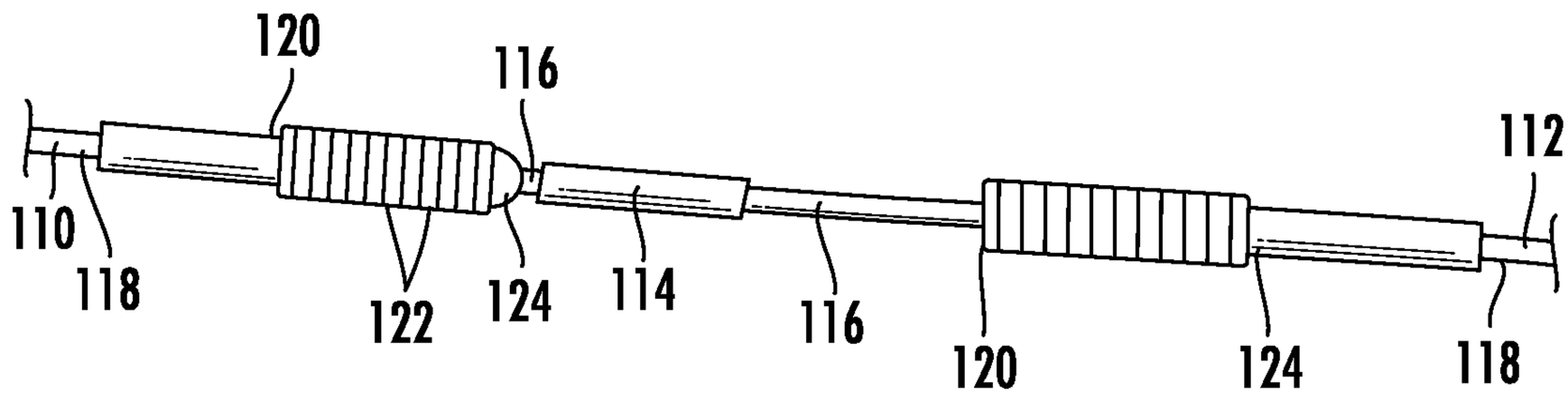

120
116
112
110
118
122
124
114
116
120
124
118

FIG. 2

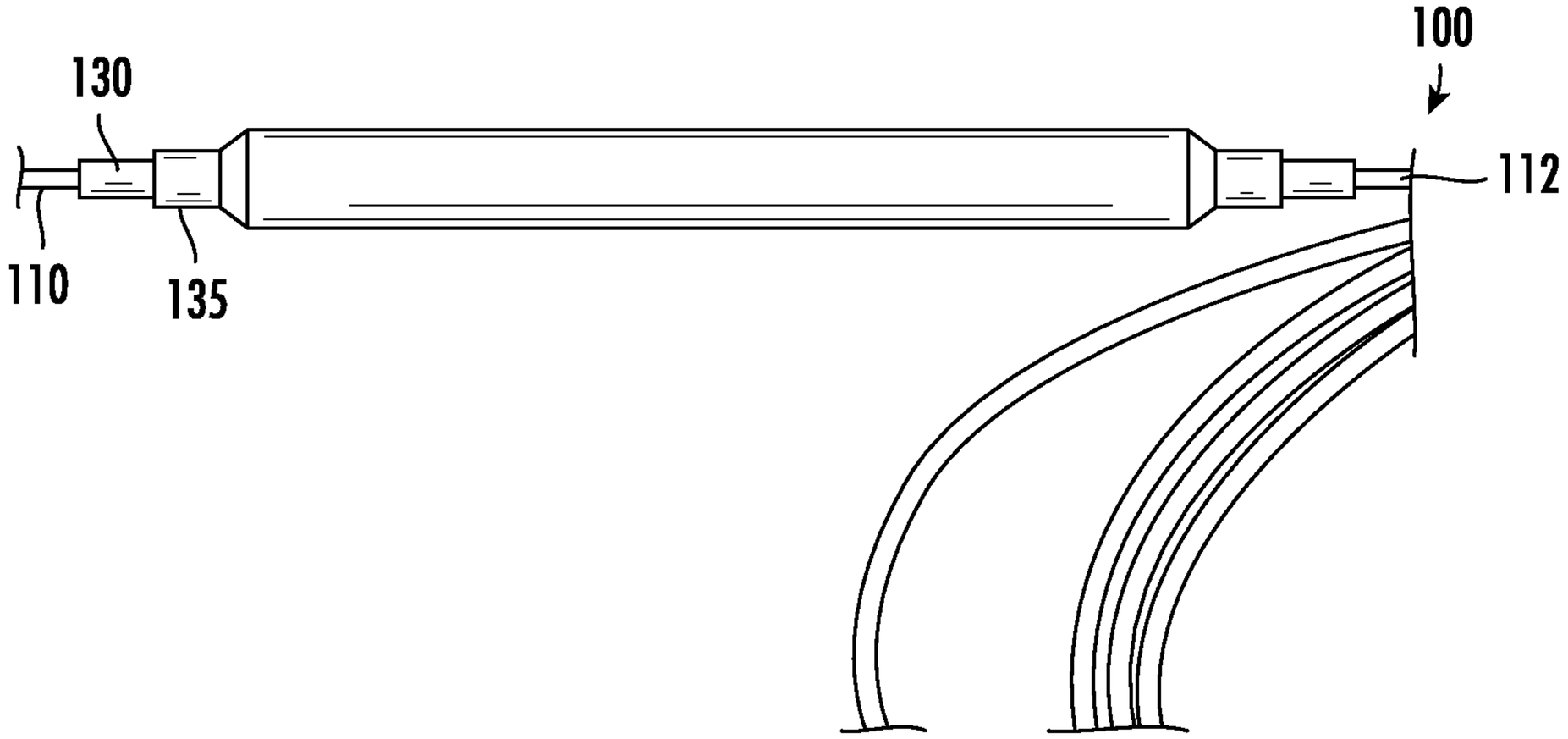


FIG. 3

FIG. 4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2020/059084

A. CLASSIFICATION OF SUBJECT MATTER

G02B 6/255(2006.01)i; **G02B 6/44**(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

G02B 6/255(2006.01); B29C 65/68(2006.01); G02B 6/245(2006.01); G02B 6/44(2006.01)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Korean utility models and applications for utility models
Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

eKOMPASS(KIPO internal) & Keywords: splice protector, optical cable, fusion, flexible, adhesive, heat-shrinkable

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2015-0160415 A1 (JEFFREY M. LLOYD et al.) 11 June 2015 (2015-06-11) See paragraphs [0024]-[0038], claim 14 and figures 1a-3.	1-6,8-11,13-21
Y		7,12,22
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A	US 2009-0324177 A1 (CHARLES QIAN et al.) 31 December 2009 (2009-12-31) See claim 1 and figures 4-5.	1-22
A	US 2017-0075067 A1 (II-VI INCORPORATED) 16 March 2017 (2017-03-16) See claim 1 and figure 1.	1-22
A	US 5894536 A (DAVID S. RIFKIN et al.) 13 April 1999 (1999-04-13) See claim 1 and figures 1-2.	1-22

☐ Further documents are listed in the continuation of Box C. ☑ See patent family annex.

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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
25 February 2021	**26 February 2021**

Name and mailing address of the ISA/KR	Authorized officer
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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
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